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Government Commodity Program Impacts on Farm Numbers

By

*Luther Tweeten**

One objective of farm commodity programs has been to maintain the family farm system as evidenced by the following quote from the Food and Agriculture Act of 1977:

> Congress hereby specifically reaffirms the historical policy of the United States to foster and encourage the family farm system of agriculture in this country. Congress firmly believes that the maintenance of the family farm system of agriculture is essential to the social well-being of the Nation and the competitive production of adequate supplies of food and fiber.

The quote begs the basic question: Do farm commodity programs help to maintain the system of family farms? This paper attempts to answer the question.

Although considerable attention has been given to government commodity programs (see Robison), their impact on farm structure remains controversial and in need of additional analysis. For manageability, I arbitrarily narrow the impact on structure to farm numbers. However, because size and numbers are highly (inversely) correlated, an analysis of farm numbers is implicitly an analysis of size. I do not attempt to predict numbers of farms by size or type. Some of these issues were ably addressed for this Committee by Richardson *et al.* and Headley in 1988.

**Anderson Professor of Agricultural Marketing, Policy, and Trade, Department of Agricultural Economics and Rural Sociology, The Ohio State University, Columbus. Paper presented at NC-181 committee on farm structure annual meeting in Albuquerque, New Mexico on January 8, 1990. Comments of Marvin Batte, Lindon Robison, and Carl Zulauf are much appreciated. Shortcomings of this study are the sole responsibility of the author.*

Brief Literature Review

Three Conflicting Conclusions

Various social scientists have reached three conflicting conclusions: In the absence of government commodity programs, the U.S. today would have (a) fewer and larger farms, (b) more and smaller farms, and (c) the same number of farms.

Programs Reduce Farm Numbers. Many social scientists contend that commodity programs have reduced the number of family farms. Quance and Tweeten (pp. 35, 36) in 1972 contended that the economic stability provided by commodity programs reduced numbers and increased size of farms. They stated that "Commodity programs reduce uncertainties and unleash the larger farmer to use his efficiency to out-compete the small farmer. Programs providing capital and security allow a given equity to be leveraged further." Quance and Tweeten also noted that programs encourage expansion of farms to utilize efficiently their machinery, labor, and other overhead as acres are diverted by government programs.

Willard Cochrane is the most outspoken current advocate of the position that commodity programs increase size and reduce the number of farms. In 1985 (p. 1008) he noted that "Maintaining the present level of price and income support helps [the moderate-size family type farm] some, but it helps their large, aggressive neighbors a lot more." He contended that commodity programs have outlived their usefulness because, in net, they contribute to loss of family farms.

The conclusion that farm programs reduce farm numbers remains very much alive. The following is a 1989 quote from Swanson (p. 15):

> The public still appears to associate farming with rural well-being, and to believe that the farm programs of the past fifty years have helped farm families. In fact, the evidence is that these programs have facilitated the decline in the number of family farms.

Programs Preserve Farms. Although they did not view the commodity program influence as decisive or large, both Gardner (p. 842) and Stanton (p. 327) concluded that government programs retarded structural change, i.e. presumably programs slowed movement to fewer, larger farms. Richardson *et al.* (p. 154) also contended that commodity programs preserve family farms:

> Based on the farm survival approach, mid-size farms having low off-farm incomes, high debts, and a high proportion of rented land benefit the most from farm programs. Without farm program benefits, it is this class of farms that is most likely to be forced out of business.

The authors reached this conclusion on the basis of farm firm simulations and on data showing direct payments by size of farm.

Programs Have No Impact. Spitze *et al.* (p. 67) concluded that "on net, the mass of data, evidence, and professional judgments provides little basis for any conclusion other than that government price and income payment policy has generally been neutral in its effect on farms of varying size." After reviewing theory and empirical data, I (Tweeten, 1984, p. 33) and Sumner (p. 284) concurred with that conclusion.

Methodologies for Measuring Structural Impacts of Policy

At least three methodologies can be utilized to evaluate the impact of commodity programs on farm structure: (1) representative farm firm analysis, (2) judgment estimates based on theory and scattered empirical observations, and (3) statistical inference from time series data. The first approach most often has concluded the programs save family farms, the second often has concluded the opposite, and a combination of (1) and (2) has led to the conclusion of no net impact. The third, a new approach, is used in this study.

Farm Firm Analysis. Farm data by economic class of farm have been widely used to judge the impact of commodity programs on farm structure. A common error of laypersons is to conclude that larger payments to large farms than to smaller farms give large farms the competitive edge and cause fewer, larger farms. This is comparable to concluding that wheat causes concentration of production on large farms because wheat receipts on larger farms exceed receipts on smaller farms. The appropriate measure of scale effect is payment per unit of farm output.

In 1988, direct payments were a major component of farm income on mid-size farms, less important on small farms, and relatively unimportant on large farms (Table 1). Payments are a large portion of farm income on mid-size farms because these farms produce enterprises covered by commodity programs and because they have high participation rates. Benefits are relatively less important on small farms because they have lower participation rates and receive more of their farm income in-kind. Payments are low relative to income (but high absolutely) on large farms because they emphasize enterprises such as livestock, fruits, and vegetables not covered by commodity programs and because payment limitations reduce participation and benefits. In short, Table 1 data clearly illustrate the importance of commodity programs to mid-size farms but do not show the dynamic impacts of programs on farm structure.

Dynamic simulation models of farm firm survivability note that large farms tend to persevere in an unstable economic environment by pursuing sophisticated risk strategies while small farms persevere by cushioning farm setbacks with off-farm income. Mid-size

Table 1. Direct Government Payments as Share of Selected Farm Economic Indicators by Sales Class of Farms, 1988.

Item	Sales Class of Farms ($1,000) 500+	250-500	100-250	40-100	20-40	10-20	5-10	Under 5	Total
Direct government payment per farm ($)	40,238	31,978	21,118	11,283	5,730	2,331	1,010	374	1,697
Payments as share of (Percent):									
Cash receipts	2.2	9.0	13.7	17.5	20.0	16.1	13.7	18.1	9.6
Gross farm income	2.1	7.8	11.5	13.6	14.3	10.1	6.8	4.8	8.0
Net farm income	5.7	24.6	42.3	64.8	87.7	88.5	89.2	Large	29.0
Total farm income, all sources	5.4	21.9	31.2	35.1	22.1	10.0	3.8	1.2	14.3

Source: U.S. Department of Agriculture (September 1989).

farms especially need government payments. However one farm-firm dynamic simulation made a case that commodity programs result in fewer, larger farms because of high savings and investment rates out of positive transitory income (Tweeten *et al.*, pp. 21-28). The shortcomings of simulation is that results depend on assumptions analysts build into the model.

Informed Judgments of Impacts. Because forces influencing farm structure are many, varied, and conflicting, and because data are not available with and without farm programs, numerous analysts have despaired of empirically determining the impact of farm commodity programs on farm structure. The alternative is to rely mainly on deductive judgments and scattered data.

A dilemma of this approach is that the various theories, scattered data, and fragmented judgments provide no weights to reach consensus from conflicting evidence. Not surprisingly, this approach mostly has brought the conclusion that commodity programs have no or small net impact on farm structure (see Spitze *et al.*, p. 67; Tweeten, 1984, p. 33; Sumner, p. 284).

Statistical Inference. Because simulation of farm firm growth and survivability and reviews of theory and fragmented data provide conflicting results, the issue of whether farm commodity programs increase, decrease, or leave unchanged farm size and numbers must be resolved empirically from a more complete model. Modest, single equation models with government payments an explanatory variable have been estimated by Gale and by Shepard and Collins. Shepard and Collins (p. 614), based on least squares statistical analysis of farm bankruptcy rates, concluded that "there is no evidence that agricultural support payments since World War II [to 1978] have induced, deferred, or reduced farm failures. As part of a pooled state cross-sectional and time series analysis of effects of prices and income on the number of farms, Gale included real government payments per farm as an explanatory variable. Because payments per farm are greater for states with large farms than for states with small farms, a positive association between farm size and government payments would be expected. Yet, Gale (p. 19) found only a "small role of government payments" in explaining farm numbers.

Time series with considerable variation in programs are now available for more comprehensive statistical inference. Thus, more comprehensive statistical models can be used to infer whether programs influence farm size and numbers. This paper mines this third approach.

I do not attempt to examine the impact of programs by sales class because (a) the issue has been treated at least conceptually elsewhere (Richardson *et al.*; Tweeten, 1984), (b) time series data by farm size classes are inadequate or require substantial massage to provide the empirical base for multivariate analysis, and (c) the definition of family farm is arbitrary. Regarding the latter, under broad definition 95 percent of farms are of the family type and have been for years (see Tweeten, 1984, p. 8). Hence trends in numbers of all farms provide insights into what is happening to family farms broadly defined. Although data and methodology of this paper are intended to improve on prior studies, results must be interpreted with caution and need to be supplemented by additional analysis as more refined data become available.

Conceptual Model

The initial conceptual model is driven by the assumption that farm operators and their families are utility maximizers and that equilibrium occurs when farm returns equal nonfarm returns. In this milieu, a small, economically inefficient farm (measuring efficiency in the narrow context of returns equal to opportunity costs of resources) can coexist with a large, economically efficient farm if the operator of the small farm is willing to pay for the farm way of life out of off-farm income. At the margin, the small farmer and the big farmer are in equilibrium because they equate marginal *social* (not just economic) returns with marginal *social* costs. It is not possible to conclude that one operator is more socially desirable or rational than the other. Of course, public subsidies differing among farm types and sizes can distort social efficiency decisions. I abstract from that issue, herein.

In equilibrium, operator labor-management return in the farm sector L equals labor-management return in the nonfarm sector L'. Farm size measured in output (real sales) is determined by the labor-output ratio. Assuming that demand for farm food and fiber output is unresponsive to price, larger output per farm implies fewer farms in the nation. We can extract considerably more information by decomposing determinants of farm size as measured by annual output S per farm into various components:

$$S = (S/X)\ (X/L)\ (L/L')\ L' \qquad (1)$$

where:

S/X is productivity measured by the ratio of aggregate farm output to aggregate input X. If aggregate land area and output demand are highly inelastic, then additional improved resource-neutral, output-increasing technology as measured by S/X increases farm size and decreases the number of farms.

L/X is the factor share of farm labor. It is essentially the inverse of aggregate output (aggregate input) per unit of labor. Changes in the variable over time reflect scale-biased, labor-substituting technology apparent in economies of farm size. *Ceteris paribus*, a change in technology giving rise to economies of size and a falling share of labor causes farm size to increase and farm numbers to decline.

L/L' is the ratio of operator and family labor income on the farm to that in the nonfarm sector. For many years after the 1930s, farm income substantially lagged nonfarm workers income. As farm income expanded to approach nonfarmers' incomes, farm size expanded. The ratio approaches 1.0 in equilibrium and hence can be dropped from (1) in the long-run. Data for recent decades indicate that farmers' and nonfarmers' per family income are somewhat comparable. Greater off-farm employment opportunity reduces pressure to expand farm size to achieve the equilibrium farm and off-farm income equal to L', other things equal. A higher proportion of farmers' income from off-farm sources FY reduces need for income from the farm and for expansion of farm size as L' grows.

L', off-farm earnings, influences farm size because, other things equal, an increase in off-farm income raises the opportunity cost of farming and hence causes farm size to grow and numbers to fall to "keep up with the Jonses."

Because equation (1) is an identity, the coefficient of each variable is hypothesized to approach unity (absolute value) in a double-log equation. The percentage change in farm size as measured by sales is equal to the sum of percentage changes in each of the right-hand-side variables in (1). Tweeten (1984) used such methodology to estimate historic sources of change in farm size and projected changes to the future.

Deterministic identity equation (1) is a useful baseline but needs considerable modification for multivariate statistical analysis. In empirical analysis the necessity to substitute proxy variables for those above and the inevitability of errors in variables and omitted variables (all cannot be included due to multicollinearity) makes the relationship in (1) inexact. Because data are more adequate to measure farm size in area rather than in real sales per farm over time, farm size is proxied by number of farms FAR. Size and numbers are closely (negatively) correlated because aggregate acres are quite fixed.

The variable SX measuring output-increasing technology can be dropped from (1) because the object is to measure size in resources or acres. However, this variable measuring aggregate productivity might be retained for another reason: An increase in aggregate productivity SX which expands output and reduces prices may drive marginal farms and excess labor out of agriculture, reducing farm numbers.

The factor share of labor (in abbreviated notation XL) represents labor-saving technology which without question has changed the face of rural America. It is such an important element that a related variable, tractor inventory (TI), is introduced to more fully account for scale-biased, labor-saving technology that has so radically altered the structure of agriculture and reduced farm numbers.[1] The price of machinery relative to labor is sometimes used in place of XL and TI although the latter are better suited to a two-step analysis where XL and TI are regressed on commodity program variables.

Closing the gap between farm and nonfarm income substantially changed farm size prior to 1950 -- the first year of data used in this study. The disequilibrium variable L/L' has been less important in recent decades and is dropped from the analysis to reduce multicollinearity.

After variables measuring commodity programs as well as prices are introduced into (1), the statistical form is depicted as

$$\mathbf{FAR = f(p, X_i, g, \epsilon)} \tag{2}$$

where p refers to a vector of price variables, X_i refers to variables from (1), g is commodity program variables, and ϵ is random error. An increase in real price of farm commodities may cause farmers to try to expand aggregate national output and acreage or for economically stronger farms to squeeze out weaker farms. Price is measured by real factor terms of trade PF, the real commodity price received per unit of resources. The variable is commodity terms of trade (parity ratio) times the productivity ratio.

Table 2. Variable Definitions and Sources

Variable[a]	Definition (Annual data from 1950 to 1987)	Source
ATFY	Permanent income measured by past 5-year moving average of deflated (by GNP price) farm income from farm and off-farm sources in million 1988 dollars.	U.S. Department of Agriculture, September 1989, p. 40 and earlier issues; Council of Economic Advisors, p. 312.
DTFD	Dummy interaction with transitory income. Variable is dummy of 1 for negative transitory income times DTFY, zero elsewhere, million 1988 dollars.	See ATFY for data source.
DTFY	Transitory income measured as deviation of total farm income t-1 from ATFY, million 1988 dollars.	See ATFY for data source.
D	Debt-asset ratio, percent.	U.S. Department of Agriculture, September 1989, p. 58.
E	Excess farm capacity as percent of total capacity . Estimated by Tweeten for 1987 to be 4 percent. Sum of acreage diversions, subsidized exports, and net stock accumulation as percent of estimated normal farm output.	Dvoskin.
FAR	Farm numbers, 1,000.	U.S. Department of Agriculture, September 1989, p. 8.
FY	Ratio of net farm income to total farm income from all sources, percent.	U.S. Department of Agriculture, September 1989.

Table 2 continued.

Variable	Definition	Source
G	Direct government payments, million 1982 dollars -- deflated by GNP deflator.	U.S. Department of Agriculture, September 1989, p. 43; Council of Economic Advisors, p. 312.
i	Real interest rate measured by non-real estate farm interest rate less GNP deflator inflation rate, percent.	U.S. Department of Agriculture, 1989 and earlier issues; Council of Economic Advisors.
NW	Farm real net worth, billion 1982 dollars.	U.S. Department of Agriculture, September 1989, p. 58; Council of Economic Advisors, p. 312.
PF	Factor terms of trade measured by real price received per unit of output produced by farm production resources. Parity ratio times productivity rate, 1977=100.	U.S. Department of Agriculture, August 1989 and June 1989; Council of Economic Advisors, p. 421.
PMPL	Ratio of farm machinery price to farm labor price, 1988=1.0.	U.S. Department of Agriculture, June 1989; Council of Economic Advisors, p. 421.
POP	Farm population, 1,000. Old farm definition used through 1981. New definition used after 1981 but dummy variable added to independent variable to allow change in intercept.	Council of Economic Advisors, 1989, p. 420.
SX	Productivity rate defined as output of crops and livestock per unit of all production inputs, 1977=100.	U.S. Department of Agriculture, August 1989, p. 50. 1989, p. 29.

Table 2 continued.

Variable	Definition	Source
TI	Tractor inventory, constant dollar real value. Tractor inventory deflated by index of prices paid by farmers for tractors and self-propelled vehicles, million 1988 dollars.	U.S. Department of Agriculture, September 1989, p. 65; U.S. Department of Agriculture, June, 1989.
V	Coefficient of variation of net farm income (deflated by GNP price index) as ratio of standard deviation of past 5-year net farm income to past 5-year mean of net farm income.	U.S. Department of Agriculture, September 1989, p. 40; Council of Economic Advisors, p. 312.
XL	Farm operator, family, and hired labor factor share, percent.	U.S. Department of Agriculture, August 1989, p. 38; Also unpublished work sheets from Economic Research Service, U.S. Department of Agriculture.

[a] Variables A for diverted acres and G' for total commodity program outlays omitted because they are not included in subsequent statistical tables.

Prices and government commodity programs also may influence FAR indirectly through behavioral relationships explaining X_i as a function of relative prices, financial conditions, commodity programs, and other variables. Hence a two-step model is proposed. The direct influence of p and g is found from statistical estimates of equation (2). The indirect influence of p and g on FAR is found by regression of the right-hand-side variables X_i in (1) on price (p), commodity program (g), other variables (d), and random error μ as below:

$$\mathbf{X_i = f(p, g, d, \mu)} \qquad (3).$$

After statistical estimation the various X_i are substituted into (2) to determine the full impact of commodity programs. Predicted values of (3) could be used in estimating (2) in a recursive formulation to avoid simultaneous equation bias. However, experience suggests that statistical efficiency loss more than offsets any gains from reduced bias in the recursive system of equations.

Commodity Programs

The analysis is restricted to 38 years of annual data (1950 through 1987) because earlier data are nonexistent, inaccurate, or from a different structure. As noted above, commodity programs are assumed to enter the equation explaining farm size either (a) directly as a shifter of the equation or of the independent variables listed earlier explaining farm numbers or (b) indirectly through equations explaining right-hand-side variables in (1).

The following variable sets (with simple correlation coefficients between them) alternatively measure farm programs:

(a) G and A $r = .83$

(b) G and E $r = .33$

(c) G'

where G is government payments to farmers, A is acres withheld from production by government diversion programs, G' is overall government spending on farm price and income supports, and E is excess capacity measured by the proportion of farm output diverted from markets by acreage diversion, export subsidy, and stock accumulation programs. These variables are used in the alternative sets rather than all at once to test various hypotheses because G and G' considerably overlap and A and E considerably overlap.

Prices, labor share, tractor inventories, and commodity program variables are presumed to influence farm numbers and not vice versa. Real interest rates can directly influence farm numbers through credit restraint or can indirectly influence numbers by changing land values.[2] Higher land values are hypothesized to retard entry into farming. Values for all variables are for the current year unless otherwise indicated in subsequent tables.

In summary, the direct influence of government programs is measured by regressions of FAR on selected core variables and the program variables listed above. Then core variables are regressed on the program variables. Results are substituted into the equation for farm numbers FAR to determine the full effects of commodity programs on farm numbers.

Specific Hypotheses

Focus is primarily on the following six hypotheses, not necessarily mutually exclusive:

Hypothesis 1: An increase in the rate of excess production capacity E (or diverted acres A) increases the size and reduces the number of farms. Farms of optimal size before diversion find they have redundant labor and machinery after diversion, hence must acquire more land to realize economies of size.

Hypothesis 2: An increase in G or G' increases the size and reduces the number of farms. Farm payments and receipts enhanced by government programs reduce internal and external capital rationing, causing farm size to grow. Farms consolidate to grow in size.

Other hypotheses work through intervening variables.

Hypothesis 3: Quance and Tweeten in 1972 contended that government programs provide stability, allowing risk-averse investors to leverage a given equity further. This hypothesis is tested by introducing equity (net worth NW) or the equity ratio (D) into the equation for FAR and into equations explaining core explanatory variables -- along with program variables as before. The hypothesis is that income variance V (reduced by programs) and the leverage ratio D or NW covary positively. That is, a given net worth or equity ratio results in fewer and larger farms in the presence of greater stability from government involvement in farming.

Hypothesis 4: The Cochrane hypothesis is that farm commodity programs provide stability and capital to increase *productivity* of farming. Increased productivity increases output and reduces farm prices and receipts, driving marginal farms out and bringing farm consolidation in. This hypothesis is tested by including SX in the equation explaining FAR and also regressing SX on variables measuring government programs. The Cochrane hypothesis is similar to the Quance-Tweeten hypothesis 3 but programs operate through productivity rather than investment.

Hypothesis 5: The permanent income hypothesis holds that farm commodity programs influence farm size and numbers primarily through the intermediary variable -- investment (see Tweeten *et al.*, pp. 21-28). Government programs reduce investment because they stabilize farm income. The propensity to invest out of permanent income is low, out of transitory positive income is high, and out of transitory negative income is near zero, the reasoning goes. For a given average farm income, greater income stability under government programs reduces positive transitory income and hence investment. Less investment means less substitution of capital for labor and hence means more and smaller farms, *ceteris paribus*.

Hypothesis 6: Government supports have opposite impacts in the short and long run. A strong case can be made that commodity programs maintain or increase farm numbers and hold down the size of farms *in the short run* because they increase survivability of marginal farms that would otherwise fail or voluntarily exit when facing unfavorable economic conditions. Large farms emphasize fruits, vegetables, livestock feeding, and other enterprises not covered by commodity programs. Small to medium-size farms are especially prominent in grains, soybeans, dairy, and tobacco enterprises covered by commodity programs. Other forces associated with government programs and expressed in the above hypotheses work to reduce farm numbers on the average *in the long run*. Thus hypothesis 6 holds that commodity programs may have opposite affects on size structure by length of run. Long- and short-run coefficients are estimated by Koyck-Nerlove distributed lag adjustment models.

Empirical Results

Each of the tables reporting empirical results has three main equations:

1. The first equation measured the contribution of prices alone to farm numbers. Of concern is whether prices alone can account for variation in farm numbers.
2. The second equation measures the contribution of government commodity programs alone. Of interest is whether government programs or prices account for more variation in farm numbers.
3. The last equation is considered to be the most adequately specified equation and is used to calculate elasticities. It is estimated both by ordinary least squares and autoregressive least squares because autocorrelation in residuals was found to be a problem in the former.

Farm Numbers Equations

1. Prices alone inadequately account for changes in farm numbers FAR over time despite significant coefficients on prices in the distributed lag equation 3.1 (Table 3). The adjusted coefficient of determination (R^2 = .519) is much lower than for the more completely specified equation 3.3.
2. Government program variables G for government payments and E for excess farm production capacity performed best but explain a small portion of variation in farm numbers (equation 3.2). The coefficient of the program variable G measuring government direct payments is statistically significant

at the .01 level. Variables measuring diverted acres and total inflation-adjusted spending on farm programs performed less well and are not included.

3. The more completely specified equation 3.3 accounts for a large proportion of the variance in farm numbers. Coefficients of all variables are significant at the .02 level or better.

4. The sign of PF reverses from 3.1 to 3.3. The expected positive sign in the more adequately specified equation 3.3 indicates that an increase in farm real prices (factor terms of trade) increases the number of farms. All variables in 3.3 display signs consistent with economic logic.

5. Except for variable lnXL, elasticities are of modest size in equation 3.3. In equation 3.3, lnXL and lnTI replace the related machinery-labor price ratio. The variable i indicates that higher real interest rates increase farm numbers perhaps because they reduce land prices, easing entry barriers.

6. Equation 3.3A is estimated by autoregressive least squares because of evidence for autocorrelated disturbances as indicated by the Durbin-Watson (DW) coefficient. Results were not fundamentally different in equations 3.3 and 3.3A.

Results for an equation explaining farm population are included as Annex Table 1. Outcomes were similar to those in Table 3 as might be expected.[3]

Table 3. Statistical Results of Least Squares Regression of Farm Numbers (FAR) on Selected Independent Variables with U.S. Annual Data from 1950 to 1987.

Equation	Constant	Independent Variables[a]								R^{2c}
		PF	PMPL	lnXL	lnTI	i	E	G	FAR(t-1)	DW
3.1										
Coef.	13518	-58.239	-4876.4						0.00163	0.519
s.e.	1652	15.802	1218.5						0.00405	
pr>|t|	<.01	<.01	<.01						0.69	0.719
SR Elast.		-2.46	-2.23							
3.2										
	4298						-21.954	-0.1508	-0.00807	0.239
	321						53.068	0.0434	0.00408	
	<.01						0.68	<.01	.06	0.153
							-0.05	-0.45		
3.3										
	-3527	448.36[b]		3194.7	-458.81	20.991	-25.625	-0.0299		0.992
	2818	263.61		98.74	179.18	8.357	6.111	0.0077		
	0.22	0.1		<.01	0.02	0.02	<.01	<.01		1.285
		0.19		1.36	-0.20	0.08	-0.06	-0.09		
3.3A[d]										
Coef.	-3807	259.28		3162.3	-341.16	17.689	-15.755	-0.0286		0.993
s.e.	2940	241.63		118.9	206.67	10.026	5.978	0.0090		
SR Elast.		0.11		1.35	-0.15	0.07	-0.04	-0.08		

[a] See Table 2 for variable definitions and sources.
[b] Variable lnPF.
[c] In this and other tables in this paper, the R^2 is adjusted for degrees of freedom.
[d] Estimated by autoregressive least squares; first-order autoregressive coefficient 0.505.

Farm Labor Factor Share Equations

1. Measured by statistical significance and adjusted R^2, prices alone do not adequately explain variation in labor factor share (equation 4.1, Table 4).
2. Commodity program variables alone in equation 4.2 do not account for much variation in labor share. Commodity programs explain much less than do prices.
3. The coefficient of the machinery-labor price ratio PMPL in equation 4.3 is highly significant but the sign is inconsistent with logic. The variable is replaced in 4.4 by an alternative form, machinery inventory TI in year t-1.
4. All coefficients have expected signs and high statistical significance in equation 4.4. Elasticities are relatively large compared to those from equations for FAR and TI.
5. Each 1 percent increase in direct government payments is projected to reduce farm numbers -.66 percent according to equation 4.4.
6. Equation 4.4A is the only instance in the entire analysis where autoregressive least squares substantially changes results. Specifically, the coefficient of G changes from a significant negative to an insignificant positive. That is very important in subsequent evaluation of the overall impact of programs because G potentially has a major impact on farm numbers through labor share given the large coefficient of XL on FAR in Table 3.

Table 4. Statistical Results of Least Squares Regression of Farm Labor Factor Share (XL) on Selected Independent Variables with U.S. Annual Data from 1950 to 1987.

Equation	Constant	Independent Variables[a]							R^2
		PF	PMPL	TI(t-1)	TIM	E	G	XL(t-1)	DW
4.1									
Coef.	96.89	-0.4548	-32.98					0.00024	0.526
s.e.	12.11	0.1182	8.80					0.00044	
pr>|t|	<.01	<.01	<.01					0.59	0.786
SE elast.		-3.00	-2.35						
4.2									
	28.24					-0.1645	-0.00095	-0.00079	0.230
	2.26					0.3934	0.00032	0.00041	
	<.01					0.68	<.01	0.06	0.170
						-0.06	-0.44		
4.3									
	75.76	-0.3585[b]	0.6539[b]		-0.2138		-0.00102	0.00603	0.773
	7.53	0.0926	0.2296		0.0532		0.00018	0.00232	
	<.01	<.01	0.01		<.01		<.01	0.01	1.219
		-2.37	0.05		-1.20		-0.47		
4.4									
	97.22	-0.4104		-0.00072	-0.0697		-0.00144		0.818
	6.73	0.0692		0.00016	0.0070		0.00016		
	<.01	<.01		<.01	<.01		<.01		1.078
		-2.71		-1.43	-0.39		-0.66		
4.4A[c]									
Coef.	71.03	-0.0017		-0.00002	-0.6612		0.00006		0.993
s.e.	7.29	0.0127		0.00004	0.0915		0.00006		
SR Elast.		-0.011		-0.04	-3.70		0.028		

[a] See Table 2 for variable definitions and sources.
[b] For t-1.
[c] Estimated by autoregressive least squares; first-order autoregressive coefficient 0.99.

The pivotal importance of the equation for XL and the significant first-order autoregressive coefficient of 0.99 in equation 4.4A prompted a further modification -- estimation of equation 4.4 in first differences. (The time variable was dropped because the intercept in the first difference equation is equivalent to the coefficient of the time variable.) The estimated coefficient of 0.00007 for G and a standard error of 0.00005 in the first difference equation were very near the results from equation 4.4A. Based on all specifications of variables and functional forms in Table 4, my judgment was that equation 4.4A coefficients are the most reliable for use in the concluding section to measure the impacts of government payments on FAR through labor share XL.

7. Variables ATFY, DTFY, and DTFD included to test the permanent income hypothesis and variable V directly and in interaction with other variables performed so poorly they are not listed in Table 4. Although improper specification may be the reason for unsatisfactory performance of variables measuring impacts of reduced instability on structure, other factors such as uncertain continuity in programs inherent in the political process (see Sumner) and the tendencies of programs to focus on income enhancement rather than economic stabilization could also be factors.

Tractor Inventory Equations

The influence of government programs on farm numbers through tractor investment is estimated from equations in Table 5. Tractor inventory is a proxy for and is closely correlated with all farm production asset inventory -- results can be interpreted accordingly.[4]

1. As in previous equations, prices alone do not perform well in explaining tractor inventory (equation 5.1).

2. Government programs account for more variation in TI (equation 5.2) than prices (equation 5.1) but only the coefficient of G is statistically significant in (5.2).

3. The ability of the permanent income hypothesis to explain tractor inventory is tested in equation 5.3 with disappointing results.

4. The hypothesis that stability as measured by V allows a given net worth to be more leveraged to increase tractor inventory is tested in equation 5.4. Using V alone or interacting with D or NW gave unacceptable results. NW performs better alone (equation 5.5) than interacting with V.

5. The independent variables in 5.5 explain 81 percent (R^2 adjusted for degrees of freedom) of the variation in TI and all coefficients display acceptable signs and statistical significance. NW may be a proxy for other correlated financial variables.

6. Autoregressive least squares equation 5.5A did not change signs or in other ways give results materially different from equation 5.5.

Table 5. Statistical Results of Least Squares Regression of Tractor Investment (TI) on Selected Independent Variables with U.S. Annual Data from 1950 to 1987.

		Independent Variables[a]										R^2
Equation	Constant	PF	PMPL	ATFY	DTFY	DTFD	NWV	NW	E	G	TI(t-1)	DW
5.1												
Coef.	16133	243.20	-16000								0.2392	0.258
s.e.	9399	76.64	6477								0.0711	
pr>|t|	0.1	<.01	-0.58								<.01	0.776
SR Elast.		0.81	-0.58									
5.2												
	34869								-282.4	-0.707	0.0704	0.442
	1821								200.3	0.1645	0.0523	
	<.01								-0.17	<.01	0.19	0.501
									-0.05	-0.16		
5.3												
	8376	191.90	-6002	0.0508	-0.0822	-0.1519				-0.7806	0.3214	0.870
	8579	62.2	6106	0.0337	0.0992	0.1800				0.1558	0.0967	
	0.34	<.01	0.33	0.14	0.41	0.41				<.01	<.01	1.420
		0.64	-0.22	0.14	-0.003	0.03				-0.18		
5.4												
	27020	138.26	-12764				16.003			-0.6253	0.1653	0.567
	8445	71.65	5550				8.249			0.1560	0.0661	
	<.01	0.06	0.03				0.06			<.01	0.02	0.933
		0.46	-0.46							-0.15		
5.5												
	39023		-20004					16.590		-0.4938	0.0695	0.812
	2908		3748					1.960		0.0967	0.0299	
	<.01		<.01					<.01		<.01	0.03	0.985
			-0.72					0.46		-0.11		
5.5A[b]												
Coef.	24063		-16853					8.927		-0.3000	0.5762	0.895
s.e.	2916		2453					1.660		0.0722	0.0826	
SR Elast.			-0.61					0.25		-0.07		

[a] See Table 2 for variable definitions and sources.
[b] Estimated by autoregressive least squares; first-order autoregressive coefficient -0.15.

7. Each 1 percent increase in direct payments is predicted to reduce farm numbers .11 percent in the short run and .12 percent in the long run according to equation 5.5, and .07 in the short run and .17 percent in the long run according to equation 5.5A.

Share of Farm Income from Farm Sources

As noted earlier in the discussion of the conceptual model, greater off-farm income reduces dependence on income from the farm for a farm family, reducing demand for farm employment *ceteris paribus*. The coefficient of the proportion of farm net income from farm sources FY was not significant in equations for FAR perhaps because of multicollinearity problems but the logic of a relationship between FY and FAR is inescapable. The impact of government program and other variables on FY is shown in Table 6.

1. Prices alone in equation 6.1 account for a considerable proportion of the variation in FY. The principal impact comes through the machinery-labor price ratio. A 10 percent increase in the relative price of machinery is predicted to raise the proportion of farm income from farm sources .1 percent in the short run and .7 percent in the long run. It may be noted that this long-run elasticity is comparable to the elasticity found in equation 6.3 without a distributed lag. Thus 6.3 may be regarded as a long-run equation.
2. Farm commodity program variables alone account for a modest share of variation in FY in equation 6.2. The specification is incomplete without other variables. None of the program variables has a significant coefficient.

Table 6. **Statistical Results of Least Squares Regression of Share of Farmers' Income from Farm Sources (FY) on Selected Independent Variables with U.S. Annual Data from 1950 to 1987.**

		Independent Variables[a]						R^2
Equation	Constant	PF(t-1)	PMPL(t-1)	TIM	E	G	FY(t-1)	DW
6.1								
Coef.	17.260	-0.1239	0.3115				0.8801	0.966
s.e.	9.139	0.0753	0.0323				0.0522	
pr> |t|	0.07	0.10	<.01				<.01	2.097
SR Elast.		-0.29	0.01					
6.2								
	20.567				-0.8737	-0.00049	0.7778	0.412
	13.034				0.7088	0.00068	0.2058	
	0.12				0.23	0.47	<.01	0.833
					-0.12	-0.08		
6.3								
	140.19		3.1855	-0.4470		-0.00545		0.869
	10.83		0.5208	0.0822		0.00396		
	<.01		<.01	<.01		<.01		2.339
			0.08	-0.89		-0.30		
6.3A[b]								
Coef.	102.96		5.5459	-0.8192		0.00037		0.899
s.e.	17.78		10.392	0.2506		0.00032		
SR Elast.			0.14	-1.64		0.06		

[a] See Table 2 for variable definitions and sources.
[b] Estimated by autoregressive least squares; first-order autoregressive coefficient 0.854.

3. The significant negative coefficient on G in equation 6.3 indicates that increased government program payments reduce the share of all farm income coming from farming. Because payments are counted as income from "farm sources" and hence raise FY, the relationship is unexpected and is probably a spurious result. The coefficient is negative probably because government payments are large when net cash receipts from farming are low.

4. Equation 6.3A estimated by autoregressive least squares shows no significant impact on FY from farm programs. Results from Table 6 are not used subsequently in the summary to calculate the impact of government programs on farm numbers.

Aggregate Farm Resource Productivity

Aggregate farm productivity SX was not included in equations of Table 3 because the objective is to measure farm numbers and size in terms of resource volume or area rather than output or sales. Also the theoretical justification for including SX as an intermediate variable measuring the impact of greater economic stability on farm numbers was not supported empirically. Selected results of various specifications of an SX equation are included in Table 7.

1. Price variables included in this study account alone for 78 (adjusted R^2) percent of the variation in productivity SX in equation 7.1. It is notable that higher factor terms of trade, a measure of incentives to expand overall resource use, do not increase productivity. In fact, higher real prices PF may reduce productivity.

2. Commodity program variables alone account for only 25 percent of the variation in SX (equation 7.2).

3. With prices included with program variables to more completely specify the equation for productivity, no program variable coefficients were significant.

4. Equation 7.3A estimated by autoregressive least squares also gives no support to the proposition that commodity programs enhance farming productivity. The sign of the PMPL coefficient changes between equations 7.3 and 7.3A, but the elasticities are so low in absolute value that the overall impact of the variable can be ignored without much injustice to reality.

Commodity programs reduce output by removing land from production but diverted acres are included in calculation of the SX denominator, all production resources. Hence, by construction, programs reduce productivity. That conclusion could be inferred from the negative coefficient of G for government programs in equation 7.3.

Results in Table 7 provide no support for the "treadmill hypothesis" that commodity programs increase productivity either directly through E and G or indirectly by improving price terms of trade PF. Hence SX is ignored in subsequent calculation of responses of farm numbers to commodity program variables.

Table 7. Statistical Results of Least Squares Regression of Aggregate Farm Productivity (SX) on Selected Independent Variables with U.S. Annual Data from 1950 to 1987.

		Independent Variables[a]						R^2
Equation	Constant	PF(t-1)	PMPL(t-1)	TIM	E	G	SX(t-1)	DW
7.1								
Coef.	49.44	-0.5817	0.5507				1.093	0.784
s.e.	19.79	0.2614	0.0869				0.114	
pr>|t|	0.02	0.03	<.01				<.01	1.590
SR Elast.		-0.49	0.01					
7.2								
	61.12				0.1687	0.00225	0.2066	0.248
	8.72				1.0480	0.00084	0.1063	
	<.01				0.87	0.01	0.06	0.364
					0.01	0.13		
7.3								
	21.21	-0.3316	-1.8040	0.3568		-0.00036	0.9037	0.928
	13.42	0.1740	0.7125	0.1087		0.00034	0.1046	
	0.12	0.07	0.02	<.01		0.30	<.01	2.452
		-0.28	-0.02	0.26		-0.002		
7.3A[b]								
Coef.	-14.16	-0.2051	6.1256	1.4848		-0.00014	0.1883	0.950
s.e.	15.69	0.1241	12.2970	0.2909		0.00031	0.1956	
SR Elast.		-0.17	0.06	1.07		-0.01		

[a] See Table 2 for variable definitions and sources.
[b] Estimated by autoregressive least squares; first-order autoregressive coefficient -0.016.

Conclusions

I conclude by responding to each of the six hypotheses listed earlier and quantify the impact of commodity programs in the short and long run. The last equation in each table is the basis for estimates and conclusions.

Hypothesis 1: An increase in diverted acres A and excess capacity E has a very minor direct impact on farm numbers (and on farm size measured in acres if aggregate acreage is fixed so numbers and size are perfectly and inversely correlated). The elasticity of FAR with respect to E is only -.06 according to equation 3.3 and only -.04 according to equation 3.3A. However, excess capacity E may influence FAR through PF.

Hypothesis 2: An increase in direct payments G (the strongest measure of program direct impacts in nearly all equations and much superior to the overall government outlays variable G', excess capacity E, or diverted acres A) does indeed seem to significantly influence farm numbers. Results are consistent with the hypothesis that commodity programs encourage farms to consolidate and grow in size and decline in numbers. However, the direct impact of a 10 percent increase in G is to decrease farm numbers by only .8 to .9 percent according to equations 3.3 and 3.3A.

Hypothesis 3: The general hypothesis that commodity programs increase farm size and decrease numbers because reduced variance of income raises labor productivity or aggregate productivity is not supported by this study.

Hypothesis 4: The Cochrane hypothesis that farm commodity programs decrease farm numbers and increase farm size is doubly rejected. That is, no statistical evidence indicated (a) that farm commodity programs increased farm resource productivity SX or (b) that SX influenced farm numbers FAR.

Hypothesis 5: This study does not support the hypothesis that programs influence income through the permanent income affect. The propensity to invest out of transitory positive income was not found to exceed the propensity from permanent income. Programs may induce stability but this study did not indicate that stability of income influenced investment or productivity.

Hypothesis 6: Results of this study indicate that commodity programs do not change farm numbers much in the short run or in the long run. Each 1 percent increase in excess capacity reduces numbers .04 to .06 percent and each 1 percent increase in government payments directly reduces numbers .08 to .09 percent (equations 3.3 nd 3.3A). But each 1 percent increase in excess capacity raises real farm prices at least 2 percent, causing farm numbers to increase .2 to .4 percent -- more than offsetting the direct impact of E and G in the short run. Thus programs in net retain farms in the short run according to the results of this analysis.

Based on the formula shown in the footnote, elasticities of farm numbers with respect to program variables in the long run are estimated to be

$$\frac{dFAR}{dE}\,\frac{E}{FAR} = -.04 \text{ in the short and long run from equation 3.3A}$$

$$\frac{dFAR}{dG}\,\frac{G}{FAR} = -.01 \text{ in the long run from equation 3.3A, 4.4A, and 5.5.}$$[5]

The result is consistent with hypothesis 6 but the magnitude of elasticities is too small to make a case the coefficients differ from zero. Furthermore, equations 3.3, 4.4, and 5.5 give a positive long-term elasticity of farm numbers with respect to more government intervention. However, the autoregressive least square result is preferred because of autocorrelation in ordinary least squares.

In short, statistical inference suggests farm commodity programs as measured herein modestly increase farm numbers in the short run and slightly decrease farm numbers in the long run. The strong impact of payments G dominates all other impacts of programs through excess capacity, acreage diversion, or total government outlays. One interpretation is that income effects from G overshadow diversion effects reflected in A and E because of slippage in controls, targeting of direct payments to farms most vulnerable to failure, or for other reasons. Another interpretation is that the variable G may be reflecting the impacts of acreage diversion because program variables are correlated. The simple correlation coefficient of G with A is .83, with E is .33, and with total government outlays G' is .59 for the 1950-87 period.

The model was formulated to favor identification of program impacts. If anything, the small impacts found would be expected to have upward bias. Analysis could be improved by more accurate data and by disaggregation by farm commodity type, size, and region. Simultaneous equation estimation techniques also might improve results.

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Annex

Annex Table 1. Statistical Results of Least Squares Regression of Farm Population (POP) on Selected Independent Variables with U.S. Annual Data from 1950 to 1987.

		Independent Variables[a]								R^2
Equation	Constant	PF(t-1)	PMPL	lnXL	lnTI	lnSX	E	G	POP(t-1)	DW
A.1										
Coef.	13831	-98.084	-2967.98						0.8285	0.985
s.e.	1326.3	8.513	1413.32						0.0202	
pr>|t|	<.01	<.01	0.04						<.01	1.951
SR Elast.		-1.66	-0.54							
A.2										
	3691						-118.24	-0.1618	0.7991	0.919
	836						93.682	0.0844	0.0448	
	<.01						0.22	0.06	<.01	0.816
							-0.11	-0.19		
A.3										
	12473	3289.45[b]		13827	-3155.77	-5484.92		-0.1494		0.994
	23171	993.50		1424	1024.15	1889.01		0.0364		
	0.54	<.01		<.01	<.01	0.01		<.01		2.01
		0.56		2.36	-0.54	-0.94		-0.18		

[a] See text Table 2 for variable definitions and sources.
[b] lnPF for year t.

1. The simple correlation coefficient between TI and SX is only -.03 for the 1950-86 period so collinearity is not a problem between these variables.

2. Off-farm earnings L' was included in the empirical model but the coefficient was insignificant. The variable was dropped to reduce multicollinearity.

3. A special effort was made to deal with the changing definition of a farm. The "old" definition ($250 of sales rather than $1,000) was retained to 1982 and the new definition used thereafter in measuring farm population. A dummy equal to 1.0 for years 1982-87, zeros elsewhere, was included as a independent variable. The coefficient was highly insignificant. One interpretation is that the tax rate reduction beginning in 1982 offset. Another is that a farm with sales of $1,000 in the late 1980s was equivalent in real size to one with $250 in sales in earlier years.

4. Total real production assets replacing TI in the model performed less well.

5. Long run elasticity where FAR=F is

$$(dF/dG)(G/F) = (\partial F/\partial G)(G/F)+[(\partial F/\partial XL)(XL/F)(\partial XL/\partial G)(G/XL)]+[(\partial F/\partial XL)(XL/F)(\partial XL/\partial TI)(TI/XL)(\partial TI/\partial G)(G/TI)]+[(\partial F/\partial TI)(TI/F)(\partial TI/\partial G)(G/TI)]$$

(Equation Source) (3.3) (3.3) (4.4A) (3.3) (4.4A) (5.5) (3.3) (5.5)